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A CONTRIBUTION TO THE PETROGRAPHY OF JAPAN

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Read before the Academy, April 17, 1916. Received, June 17, 1916

It has been known for many years that the volcanic lavas of the Japanese islands are chiefly pyroxene-andesites, and that other lavas are more siliceous and some less so, but the actual chemical composition of most of them has long remained unknown, though chemical analyses of a few varieties have been published. This was the case to within a few years, when some of the principal volcanoes were visited by one of us in order to study various forms of craters of a few of the many active volcanoes of this region, and to collect material for chemical and microscopical study. Since that time a number of excellent chemical analyses of igneous rocks have been made in the laboratory of the Imperial Geological Survey of Japan, some of which have been published in volume 2 of *Igneous Rock* by J. P. Iddings.

The accompanying seventeen analyses, by E. W. Morley, furnish new chemical data relating to lavas of several of the most prominent Japanese volcanoes, and form a series from the basalts, or basaltic andesites, of Fuji yama and Aso to dacites and rhyolites of less well-known localities.

The habit of the pyroxene-andesites is much the same in all the varieties collected, except that some are compact rocks, others vesicular. They have abundant small phenocrysts, that is, they are sempatic and seriate minophyric. The most abundant phenocrysts are strongly calcic feldspars. Pyroxenes are inconspicuous and are in large part hypersthene, the relative amounts of augite and hypersthene varying considerably. Olivine occurs as phenocrysts in few of the rocks analyzed, and quartz phenocrysts in a few. Magnetite is abundant in most of the andesites, chiefly as microscopic constituents of the groundmass together with microlites of feldspar and pyroxene. It also forms small phenocrysts.

While the lavas at each volcano vary somewhat in composition, the variation is within narrow limits so far as observed. The material analyzed represents characteristic rock from each locality, but not all that occurs there. Analysis 1 is of the rock from the Hoyei crater on the east slope of Fuji yama. The rock is basalt with andesitic habit, and contains abundant olivine and is the lowest in silica of the rocks analyzed. Nevertheless, the calculated norm contains a small amount of quartz with considerable normative hypersthene. The normative feldspar is strongly calcic.

Recent lava from the north rim of the central crater of the volcano Aso, is pyroxene-andesite, anal. 2, with nearly the same chemical composition as the basalt from Fuji yama, and with slightly more normative quartz, but no modal olivine, so far as observed. The normative feldspar is less calcic and there is less of the femic components. The chemical resemblance between the two rocks is well shown by the symbols and magmatic names.

The lava of Niokiba crater, Nazu volcano, which was erupted in 1881, anal. 3, is typical bandaite, that is, it is a pyroxene-andesite with laboradorite feldspars and a notable amount of normative quartz, some of which appears as quartz phenocrysts. The next six rocks, anals. 4 to 9, are pyroxene-andesites, which are transitional bandaites, since the normative feldspars are andesine-laboradorite. The lavas occur at widely scattered volcanoes, Zao San, Asama yama and Azuma yama on the main island, Hondo; Ohachi, and Shimasaki, a quarry near Kumamoto, on Kyushu; and Komagatake, on Hokkaido.

The lava erupted from Tarumai, Hokkaido, in 1909, anal. 10, is chemically similar to the preceding, but the feldspars are slightly less calcic. It is a transitional variety of pyroxene-andesite related to bandaite. The andesite from the rim of the central crater of Iwakisan, in northern Hondo, anal. 11, is closely similar to bandaite, with somewhat less pyroxene. The rock from the southern summit of Sakurajima, Kyushu, anal. 12, which was collected in 1910, before the last great eruption of this volcano, is a glassy pyroxene-andesite, having the chemical composition of an andesine-dacite, or shastaite. The hornblende-mica-andesite of Mae yama, near Shimabara, anal. 13, and the spherulitic dacite from Kōsaka, Hondo, anal. 14, are chemically similar, though modally quite unlike. They may be classed as shastaites, because of the character of their normative feldspars. The glassy dacite, anal. 15, from near the Shinyu Inn at the west base of Aso, Kyushu, is a variety of ungaite, judging by the norm. The normative plagioclase is oligoclase, with which is subordinate normative orthoclase. It may be classed as an oligoclase-dacite transitional to dellenite.

Analysis 16 is of a garnet-bearing rhyolitic obsidian, from Hiwashima, and analysis 17 is of a spherulitic rhyloitic obsidian said to occur on the sea coast north of Kagoshima and Sakarajima. The seventeen analyses show that there is a strong chemical likeness among the rocks collected, which is well brought out by the norms and magmatic symbols.

TABLE OF CHEMICAL ANALYSES AND NORMS OF JAPANESE LAVAS

	1	2	3	4	5	6	7	8
SiO_2	50.61	53.38	58.93	57.04	57.75	59.27	59.79	60.95
Al_2O_3	17.84	18.15	16.56	15.78	17.50	16.66	17.41	16.30
Fe_2O_3	2.97	2.27	2.82	2.36	3.45	1.56	1.84	2.47
FeO	7.12	6.21	4.36	5.37	3.54	4.79	4.27	4.05
MgO	5.99	3.60	3.81	4.44	3.87	3.97	3.19	3.27
CaO	10.14	9.60	7.84	7.54	7.45	7.77	7.34	7.29
Na_2O	2.48	2.89	2.34	2.74	2.83	2.92	2.71	2.50
K_2O	0.74	1.75	1.00	1.31	1.33	1.03	1.85	1.68
H_2O-	0.00	0.00	0.25	0.39	0.17	0.00	0.00	0.12
H_2O+	0.39	0.14	0.71	1.32	0.44	0.16	0.11	0.32
TiO_2	0.66	0.86	0.59	0.79	0.67	0.81	0.63	0.60
P_2O_5	0.34	0.29	0.15	0.19	0.26	0.55	0.33	0.07
MnO	0.80	0.43	0.44	0.44	0.53	0.35	0.15	0.19
ZrO_2	0.00	0.00	0.00	0.02	0.01	0.01	0.01	0.00
CO_2	0.00	0.01	0.03	0.00	0.01	0.01	0.00	0.00
Cl	0.08	0.05	0.07	0.12	0.06	0.06	0.14	0.09
F	0.04	0.10	0.08	0.08	0.03	0.02	0.07	0.02
S	0.03	0.02	0.02	0.05	0.08	0.06	0.08	0.05
Cr_2O_3	0.02	0.00	0.01	0.01	0.01	0.00	0.00	0.00
BaO	0.03	0.04	0.02	0.08	0.04	0.03	0.08	0.04
SrO	0.02	0.03	0.00	0.01	0.02	0.04	0.04	0.02
	100.30	99.82	100.02	100.08	100.05	100.07	100.04	100.03

Norms

	1	2	3	4	5	6	7	8
q	1.38	3.66	18.42	12.42	14.52	15.42	15.60	19.32
or	4.45	10.56	5.56	7.78	7.78	6.12	11.12	10.01
ab	20.96	24.63	19.91	23.06	24.10	24.63	23.06	20.96
an	35.31	31.14	31.97	26.97	31.14	29.47	29.75	28.36
c								
di	10.63	11.77	4.73	7.94	3.13	4.54	3.86	6.31
hy	20.64	12.10	12.62	14.61	11.64	14.54	11.65	9.37
mt	4.41	3.25	4.18	3.48	5.10	2.32	2.55	3.71
hm								
il	1.37	1.67	1.22	1.52	1.22	1.52	1.22	1.22
ap	0.67	0.67	0.34	0.34	0.67	1.34	0.67	
etc	0.61	0.38	1.16	2.08	0.86	0.38	0.53	0.66
	100.43	99.83	100.11	100.20	100.16	100.28	100.01	99.92

1. Basalt, hessose-auvergnose, (II) III.5.4.4'. Fuji yama.
2. Pyroxene-andesite, andose-hessose, II.5.(3) 4.4. Aso, central crater.
3. Pyroxene-andesite, bandaite, bandose, II.4.4.4. Nazu, lava 1881.
4. Pyroxene-andesite, tonalose-bandose, II.4'.(3) 4.4. Zao San.
5. Pyroxene-andesite, tonalose-bandose, II.4.(3) 4.4. Shimasaki, Kumamoto
6. Pyroxene-andesite, tonalose-bandose, II.4.(3) 4.4. Asama yama, erupt. 1909.
7. Pyroxene-andesite, tonalose-bandose, II.4.(3) 4.'4. Ohachi, Takachiho,
8. Pyroxene-andesite, tonalose-bandose, II.4.(3) 4.4. Azuma yama, lava 1893.
9. Pyroxene-andesite, tonalose-bandose, 'II.4.(3) 4.4'. Komagatake, Hokkaido.

Table of Chemical Analyses and Norms of Japanese Lavas

9	10	11	12	13	14	15	16	17
59.76	58.63	61.89	64.98	65.89	70.43	70.72	73.64	76.64
17.69	17.32	17.89	15.89	16.02	15.55	14.79	14.35	12.08
5.13	4.53	3.73	1.89	1.97	1.24	0.75	0.40	0.73
2.16	3.12	1.66	4.22	2.16	1.19	1.35	0.99	0.66
2.65	2.98	2.09	1.83	2.20	0.78	0.94	0.21	0.24
6.97	7.40	6.48	3.22	3.93	3.53	1.50	0.63	1.28
3.15	3.50	3.39	3.31	3.67	4.08	4.19	4.33	3.54
0.93	1.20	1.19	1.87	2.67	1.41	4.25	3.79	3.11
0.09	0.01	0.18	0.04	0.00	0.42	0.02	0.04	0.00
0.24	0.12	0.27	0.62	0.31	0.71	0.57	0.47	0.99
0.56	0.54	0.50	0.75	0.51	0.13	0.34	0.03	0.25
0.23	0.12	0.01	0.26	0.26	0.12	0.12	0.23	0.12
0.44	0.13	0.09	0.70	0.42	0.15	0.23	0.18	0.32
0.00	0.00	n. d.	0.02	0.00	0.00	0.00	0.00	0.01
0.02	0.01	0.02	0.01	0.01	0.02	0.01	0.02	0.01
0.10	0.06	0.14	0.12	0.06	0.05	0.06	0.18	0.19
0.03	0.06	0.03	0.05	0.05	0.06	0.05	0.03	0.05
0.03	0.03	0.09	0.07	0.02	0.06	0.02	0.14	0.06
0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00
0.05	0.06	0.04	0.10	0.06	0.04	0.04	0.16	0.06
0.04	0.03	0.00	0.00	0.00	0.04	0.06	0.00	0.00
100.27	99.85	99.71	99.95	100.21	100.01	100.03	99.82	100.34

Norms

19.86	14.82	20.94	27.18	22.32	32.46	24.60	32.34	41.10
5.56	7.23	7.23	11.12	16.12	8.34	25.58	22.24	18.35
26.72	29.34	28.82	27.77	30.92	34.58	35.63	36.68	29.87
31.41	28.08	29.75	13.90	17.51	16.68	6.67	1.39	5.56
			3.37	0.61	1.22	0.71	2.65	0.92
1.51	6.15	1.73						
5.90	6.06	4.40	10.67	7.74	3.09	4.12	2.22	1.39
6.73	6.50	4.18	2.78	3.02	1.86	1.16	0.70	0.93
0.48		0.80						
1.06	0.91	0.91	1.37	0.91	0.30	0.64		0.46
0.34	0.34		0.67	0.67	0.34	0.34	0.67	0.34
0.58	0.37	0.77	1.02	0.50	1.38	0.85	1.02	1.36
100.15	99.80	99.53	99.85	100.32	100.25	100.30	99.91	100.18

10. Pyroxene-andesite, bandose-tonalose, II.4′.3′.4. Tarumai, lava 1909.
11. Pyroxene-andesite, bandose-yellowstonose, I (II).4.(3) 4.4. Iwakisan.
12. Pyroxene-andesite, shastaite, dacose-tonalose, ′II.′4.′3.4. Sakurajima.
13. Hornblende-mica-andesite, tonalose-yellowstonose, I (II).4.′3.′4. Mae yama, Shimabara.
14. Spherulitic dacite,-yellowstonose, I.(3) 4.′3.4′. Kosaka.
15. Glassy dacite, lassenose-toscanose, I′.4.′2.3 (4). Aso, west base, above Shinyu Inn.
16. Rhyolitic obsidian, liparose-kallarudose, I.(3) 4.1.(3) 4. Hiwashima.
17. Spherulitic rhyolite, tehamose-alsbachose, I.3′.′2.(3) 4. Coast north of Kagoshima.